A **parallel** or parallel of latitude is a circle on the

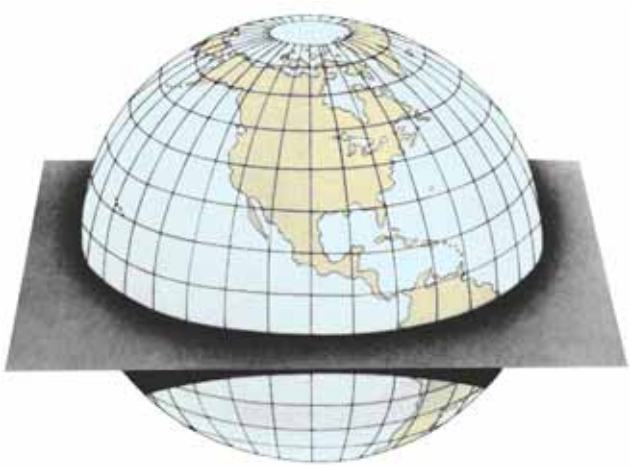

Figure 104b. The equator is a great circle midway between the poles.

surface of the Earth parallel to the plane of the equator. It connects all points of equal latitude. The **equator** is a great circle at latitude 0° that bisects the Northern and Southern Hemispheres. See Figure 104b. The poles are single points at latitude 90°. All other parallels are small circles.

105. Coordinates

Coordinates of latitude and longitude can define any position on Earth. **Latitude (L, lat.)** is the angular distance from the equator, measured northward or southward along a meridian from 0° at the equator to 90° at the poles. It is designated north (N) or south (S) to indicate the direction of measurement.

The **difference of latitude (*l*, DLat.)** between two places is the angular length of arc of any meridian between their parallels. It is the numerical difference of the latitudes if the places are on the same side of the equator; it is the sum of the latitudes if the places are on opposite sides of the equator. It may be designated north (N) or south (S) when appropriate. The middle or **mid-latitude (Lm)** between two places on the same side of the equator is half the sum of their latitudes. Mid-latitude is labeled N or S to indicate whether it is north or south of the equator.

The expression may refer to the mid-latitude of two places on opposite sides of the equator. In this case, it is equal to half the difference between the two latitudes and takes the name of the place farthest from the equator.

Longitude (l, long.) is the angular distance between the prime meridian and the meridian of a point on the Earth, measured eastward or westward from the prime meridian through 180°. It is designated east (E) or west (W) to indicate the direction of measurement.

The **difference of longitude (DLo)** between two places is the shorter arc of the parallel or the smaller angle at the pole between the meridians of the two places. If both places are on the same side (east or west) of Greenwich, DLo is the numerical difference of the longitudes of the two places; if on opposite sides, DLo is the numerical sum unless this exceeds 180°, when it is 360° minus the sum.

The distance between two meridians at any parallel of latitude, expressed in distance units, usually nautical miles, is called **departure (p, Dep.)**. It represents distance made good east or west as a craft proceeds from one point to another. Its numerical value between any two meridians decreases with increased latitude, while DLo is numerically the same at any latitude. Either DLo or p may be designated east (E) or west (W) when appropriate.

106. Distance on the Earth

Distance, as used by the navigator, is the length of the **rhumb line** connecting two places. This is a line making the same angle with all meridians. Meridians and parallels which also maintain constant true directions may be considered special cases of the rhumb line. Any other rhumb line spirals toward the pole, forming a **loxodromic curve** or **loxodrome**. See Figure 106a below for image depicting

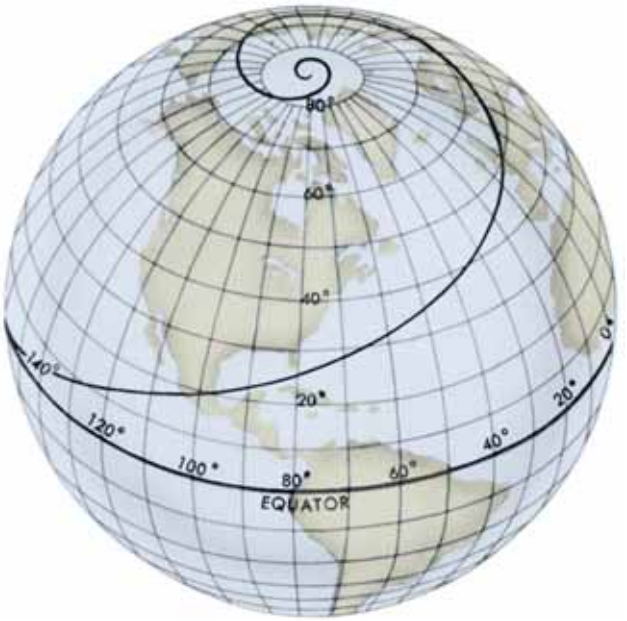

Figure 106a. A loxodrome.

a loxodrome curve.

Distance along the great circle connecting two points is customarily designated **great-circle distance**. For most purposes, considering the nautical mile the length of one minute of latitude introduces no significant error.

Speed (S) is rate of motion, or distance per unit of time. A **knot (kn.)**, the unit of speed commonly used in navigation, is a rate of 1 nautical mile per hour. The expression **speed of advance (SOA)** is used to indicate the speed to be made along the intended track. **Speed over the ground**

information not needed at a given time. By comparison, the paper chart and its raster equivalent is an unchangeable diagram. A second advantage is the ability to orient the display course-up when this is convenient, while the text remains screen-up.

Taking advantage of affordable yet high-powered computers, some ECDIS and ECS now permit a split screen display, where mode of motion, orientation and scale are individually selectable on each panel. This permits, for example, a north-up small-scale overview in true motion alongside a course-up large-scale view in relative motion. Yet another display advantage occurs with zooming, in that symbols and text describing areas center themselves automatically in whatever part of the area appears on the screen. None of these functions are possible with raster charts.

The display operates by a set of rules, and data is arranged hierarchically, For example, where lines overlap, the less important line is not drawn. A more complex rule always places text at the same position relative to the object it applies to, no matter what else may be there. Since a long name or light description will often over-write another object, the only solution is to zoom in until the objects separate from each other. Text is written automatically when the object it refers to is on the display. Because it causes so much clutter, and is seldom vital for safe navigation, it, text portrayal is an option under the "all other information" display level.

Flexibility in display scale requires some indication of distance to objects seen on the display. Some manufacturers use the rather restrictive but familiar radar range rings to provide this, while another uses a line symbol keyed to data's original scale. The ECDIS design also includes a one-mile scalebar at the side of the display, and an optionally displayed course and speed-made-good vector for own ship. There may be a heading line leading from the vessel's position indicating her future track for one minute, three minutes, or some other selectable time.

To provide the option of creating manual chart corrections, ECDIS includes a means of drawing lines, adding text and inserting stored objects on the display. These may be saved as user files, called up from a subdirectory, and edited on the display. Once loaded into the SENC, the objects may be selected or de-selected just as with other objects of the SENC.

Display options for ECDIS and ECS include transfer of ARPA-acquired targets and radar image overlay. IMO standards for ECDIS require that the operator be able to deselect the radar picture from the chart with a single operator action for fast "uncluttering" of the chart presentation.

In the 2014 Presentation Library update, several changes were made to include:

- A new "Detection and Notification of Navigational Hazard" section: For each ENC feature and its associated attributes, ECDIS will define the priority of an alert to be raised when a navigational hazard is detected.
- A new "Detection of Areas, for which Special Conditions Exist" section: This lists the ENC features and attributes that will raise an indication or alert in the ECDIS as defined by the mariner.
- The ability to turn on and off isolated dangers in shallow water.
- New standardized symbols to identify where automatic ENC updates have been applied and indicate where features with temporal attributes are located.
- Display names of anchorage areas and fairways.
- A means for the mariner to insert a date or date range within the ECDIS to display date dependent features.

507. Units, Data Layers and Calculations

ECDIS uses the following units of measure:

- **Position:** Latitude and longitude will be shown in degrees, minutes, and decimal minutes, normally based on WGS-84 datum.
- **Depth:** Depths will be indicated in meters and decimeters.
- **Height:** Meters
- **Distance:** Nautical miles and tenths, or meters
- **Speed:** Knots and tenths

ECDIS requires data layers to establish a priority of data displayed. The minimum number of information categories required and their relative priority from highest to lowest are listed below:

- ECDIS warnings and messages
- Hydrographic office data
- *Notice to Mariners* information
- Hydrographic office cautions
- Hydrographic office color-fill area data
- Hydrographic office on demand data
- Radar information
- User's data
- Manufacturer's data
- User's color-fill area data
- Manufacturer's color-fill area data

As a minimum, an ECDIS system must be able to perform the following calculations and conversions:

- Geographical coordinates to display coordinates, and display coordinates to geographical coordinates.
- Transformation from local datum to WGS-84.
- True distance and azimuth between two geographical positions.
- Geographic position from a known position given distance and azimuth.
- Projection calculations such as great circle and rhumb line courses and distances.

508. Alerts and Indications

Knowledge and ability to interpret and react to the

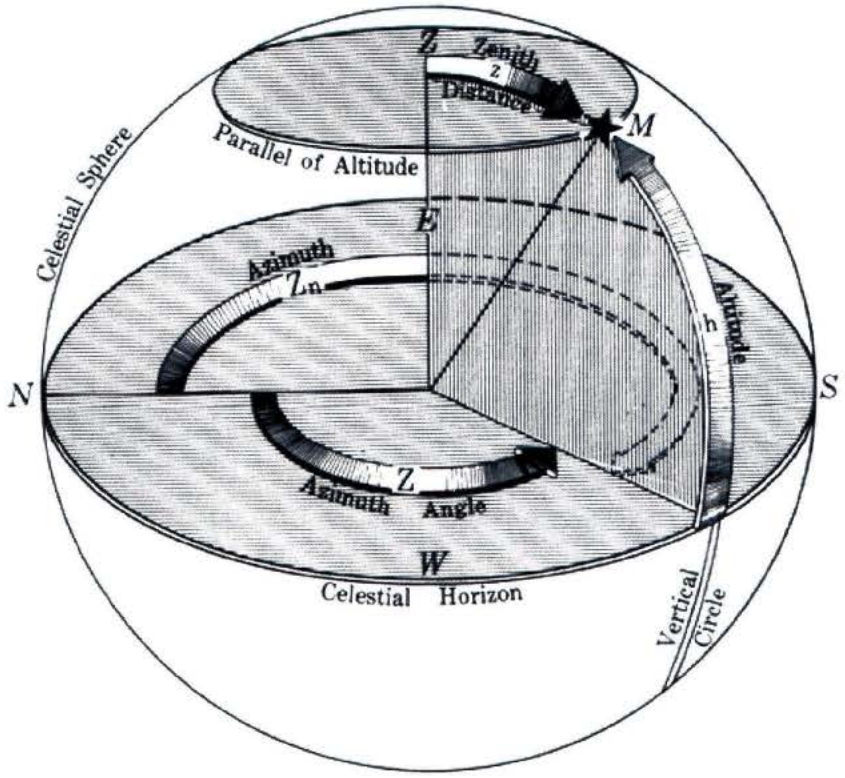

Figure 1329b. Elements of the celestial sphere. The celestial horizon.

lies in the ecliptic and the planes of the orbits of the Moon and planets are near the ecliptic. Because the planes of their orbits lie near the ecliptic, it is easier to predict the positions of the Sun, Moon, and planets using ecliptic coordinates.

The four systems of celestial coordinates are analogous to each other and to the terrestrial system, although each has distinctions such as differences in primary reference planes. Table 1329 indicates the analogous term or terms under each system. Also see Table 1330.

NAVIGATIONAL COORDINATES

Coordinate	Symbol	Measured from	Measured along	Direction	Measured to	Units	Precision	Maximum value	Labels
latitude	L, lat.	equator	meridian	N, S	parallel	°, ¢	0¢.1	90°	N, S
colatitude	colat.	poles	meridian	S, N	parallel	°, ¢	0¢.1	90°	—
longitude	l, long.	prime meridian	parallel	E, W	local meridian	°, ¢	0¢.1	180°	E, W
declination	d, dec.	celestial equator	hour circle	N, S	parallel of declination	°, ¢	0¢.1	90°	N, S
polar distance	p	elevated pole	hour circle	S, N	parallel of declination	°, ¢	0¢.1	180°	—
altitude	h	horizon	vertical circle	up	parallel of altitude	°, ¢	0¢.1	90°*	—
zenith distance	z	zenith	vertical circle	down	parallel of altitude	°, ¢	0¢.1	180°	—

Table 1330. Navigational Coordinates.

OPNAV 3530/40 (4-73) LAT BY POLARIS	NAVIGATION WORKBOOK OPNAV 3530/1 (Rev. 7-74)
Date	DATE/DR POSIT 22 Mar 2016 40° 46' N, 043° 22.0' W
Body	Polaris
GMT	23-18-56
IC	
D	
Sum	
Hs	
Ha	
Alt Corr	
Add'l Corr	
Ho	40° 52.1'
GHAγ (h)	165° 52.3'
Incre (m/s)	4° 44.8'
Total GHAγ	170° 37.1'
± 360°	—
DRλ (+E –W)	-43° 22.0'
LHAγ	127° 15.1'
A0	54.9'
A1	0.5'
A2	0.9'
Sum	56.3'
1° 00' (-)	-1° 00.0'
Total Corr	-3.7'
Ho	40° 52.1'
LAT	N 40° 48.4'
Time	
Sounding	
Signature	

Figure 1912a. Sight reduction strip form for longitude by Polaris.

GHA for the hour the sight was taken (165° 52.3'). Then determine the incremental addition for the minutes and seconds after the hour from the Increments and Corrections table in the back of the *Nautical Almanac* (4° 44.8'). The total GHA of Aries is 170° 37.1'. As described above, LHA is GHA - λ for west longitudes and GHA + λ for east longitudes. Because our example DR is in the western hemisphere, subtract the DR longitude from the GHA to obtain the LHA of Aries, 127° 15.1'.

Next, enter the Polaris table with the calculated LHA of Aries at the time of observation (127° 15.1'). The first correction, A_0, is a function solely of the LHA of Aries. Enter the table column indicating the proper range of LHA of Aries; in this case, enter the 120°-129° column. The numbers on the left hand side of the A_0 correction table represent the whole degrees of LHA ♈; interpolate to determine the proper A_0 correction. In this case, LHA ♈ was 127° 15.1'. The A_0 correction for LHA = 127° 54.7' and the A_0 correction for LHA = 128° is 55.4'. The A_0 correction for 127° 15.1' is 54.9'.

To calculate the A_1 correction, enter the A_1 correction table with the DR latitude, being careful to stay in the 120°-129° LHA column. There is no need to interpolate here; simply choose the latitude that is closest to the vessel's DR latitude. In this case, L is 40°N. The A_1 correction corresponding to an LHA range of 120°-129° and a latitude of 40°N is + 0.5'.

Finally, to calculate the A_2 correction factor, stay in the 120°-129° LHA ♈ column and enter the A_2 correction table. Follow the column down to the month of the year; in this case, it is March. The correction for March is + 0.9'.

Sum the corrections, remembering that all three are always positive (56.3'). Subtract 1° from the sum to determine the total correction (-3.7'), then apply the resulting value to the observed altitude of Polaris. The result is the vessel's latitude, N 40° 48.4'.

THE DAY'S WORK IN CELESTIAL NAVIGATION

1913. Celestial Navigation Daily Routine

The navigator need not follow the entire celestial routine if celestial navigation is not the primary navigation method. It is appropriate to use only the steps of the celestial day's work that are necessary to provide a meaningful check on the primary fix source and maintain competency in celestial techniques.

The list of procedures below provides a complete daily celestial routine to follow. This sequence works equally well for all sight reduction methods, whether tabular, mathematical, computer program, or celestial navigation

APPENDIX B

CALCULATIONS AND CONVERSIONS

INTRODUCTION

App B 1. Purpose and Scope

This chapter discusses the use of calculators and computers in navigation and summarizes the formulas the navigator depends on during voyage planning, piloting, celestial navigation, and various related tasks. To fully utilize this chapter, the navigator should be competent in basic mathematics including algebra and trigonometry (See Chapter 1 - Mathematics in Volume II) and be familiar with the use of a basic scientific calculator. The navigator should choose a calculator based on personal needs, which may vary greatly from person to person according to individual abilities and responsibilities.

App B 2. Use of Calculators in Navigation

Any common calculator can be used in navigation, even one providing only the four basic arithmetic functions of addition, subtraction, multiplication, and division. Any good scientific calculator can be used for sight reduction, sailings, and other tasks. However, the use computer applications and handheld calculators specifically designed for navigation will greatly reduce the workload of the navigator, reduce the possibility of errors, and assure accuracy of the results calculated.

Calculations of position based on celestial observations have become increasingly uncommon since the advent of GPS as a dependable position reference for all modes of navigation. This is especially true since GPS units provide worldwide positioning with far greater accuracy and reliability than celestial navigation.

However, for those who use celestial techniques, a celestial navigation calculator or computer application can improve celestial position accuracy by easily solving numerous sights, and by reducing mathematical and tabular errors inherent in the manual sight reduction process. They can also provide weighted plots of the LOP's from any number of celestial bodies, based on the navigator's subjective analysis of each sight, and calculate the best fix with latitude/longitude readout.

In using a calculator for any navigational task, it is important to remember that the accuracy of the result, even if carried out many decimal places, is only as good as the least accurate entry. If a sextant observation is taken to an accuracy of only a minute, that is the best accuracy of the final solution, regardless the calculator's ability to solve to 12 decimal places. See Chapter 3 - Navigational Error in Volume II for a discussion of the sources of error in navigation.

Some basic calculators require the conversion of degrees, minutes and seconds (or tenths) to decimal degrees before solution. A good navigational calculator, however, should permit entry of degrees, minutes and tenths of minutes directly, and should do conversions automatically. Though many non-navigational computer programs have an on-screen calculator, they are generally very simple versions with only the four basic arithmetical functions. They are thus too simple for complex navigational problems. Conversely, a good navigational computer program requires no calculator per se, since the desired answer is calculated automatically from the entered data.

The following articles discuss calculations involved in various aspects of navigation.

App B 3. Calculations of Piloting

- **Hull speed in knots** is found by:

  $$S = 1.34\sqrt{\text{waterline length}} \text{ (in feet)}.$$

  This is an approximate value which varies with hull shape.

- **Nautical and U.S. survey miles** can be interconverted by the relationships:

  1 nautical mile = 1.15077945 U.S. survey miles.

  1 U.S. survey mile = 0.86897624 nautical miles.

- **The speed of a vessel over a measured mile** can be calculated by the formula:

  $$S = \frac{3600}{T}$$

  where S is the speed in knots and T is the time in seconds.

- **The distance traveled at a given speed** is computed

obtained by subtracting 51508 from 51521 (the logarithm for 3275) to obtain 13, multiplying this by 0.7, and adding the result (9) to 51508.

Tables 1 (Logarithms of Numbers) and Table 2 (Natural Trigonometric Functions) provide the difference between consecutive entries, but no proportional parts tables.

The *Nautical Almanac* "Increments and Corrections" are interpolation tables for the hourly entries of Greenwich Hour Angle (GHA) and declination. The increments are the products of the constant value used as the change of GHA in 1 hour and the fractional part of the hour. The corrections provide for the difference between the actual change of GHA in 1 hour and the constant value used. The corrections also provide the product of the change in declination in 1 hour and the fractional part of the hour.

The main part of the four-page interpolation table of *Pub. No. 229* is basically a multiplication table providing tabulations of:

$$\text{Altitude Difference} \times \frac{\text{Declination Increment}}{60'}$$

The design of the table is such that the desired product must be derived from component parts of the altitude difference. The first part is a multiple of 10' (10', 20', 30', 40', or 50') of the altitude difference; the second part is the remainder in the range 0.0' to 9.9'. For example, the component parts of altitude difference 44.3' are 40' and 4.3'.

In the use of the first part of the altitude difference, the table arguments are declination increment (Dec. Inc.) and the integral multiple of 10' in the altitude difference, d. As shown in Figure 205a, the respondent is:

$$\text{Tens} \times \frac{\text{Dec. Inc.}}{60'}\,.$$

In the use of the second part of the altitude difference, the interpolation table arguments are the nearest Dec. Inc. ending in 0.5' and Units and Decimals. The respondent is:

$$\text{Units and Decimals} \times \frac{\text{Dec. Inc.}}{60'}\,.$$

In computing the table, the values in the Tens part of the multiplication table were modified by small quantities varying from -0.042' to +0.033' before rounding to the tabular precision to compensate for any difference between the actual Dec. Inc. and the nearest Dec. Inc. ending in 0.5' when using the Units and Decimals part of the table.

Using the interpolation table shown in Figure 205b to obtain the altitude for 51°30' from the data of Table 204b (*Data from Pub. No. 229)*, the linear correction for the first difference (+0.5') is +0.3'. This correction is extracted from the Units and Decimals block opposite the Dec. Inc. (30.0').

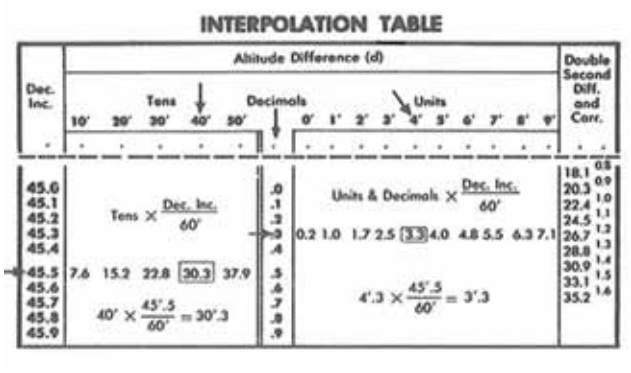

Figure 205a. Interpolation table.

The correction for the **double second difference (DSD)** is extracted from the DSD subtable opposite the block in which the Dec. Inc. is found. The argument for entering this critical table is the DSD (-4.4'). The DSD correction is +0.3'. Therefore,

$$\text{Hc} = \text{ht} + \text{first difference correction} + \text{DSD correction}$$
$$= 64°11.0' + 0.3' + 0.3' = 64°11.6'\,.$$

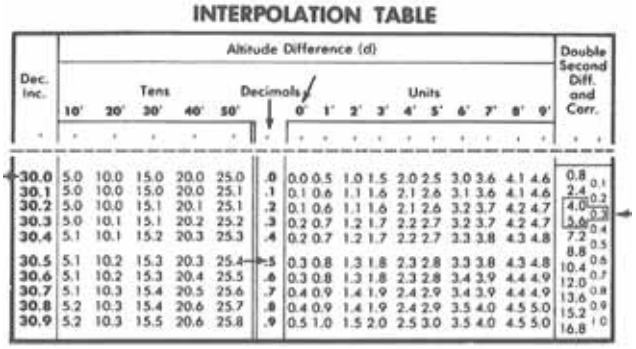

Figure 205b. Interpolation table.

More on Second Differences using Pub 229. The accuracy of linear interpolation usually decreases as the altitude increases. At altitudes above 60° it may be necessary to include the effect of second differences in the interpolation. When the altitude difference, d, is printed in italic type followed by a small dot, the second-difference correction may exceed 0.25', and should normally be applied. The need for a second-difference correction is illustrated by the graph of Table 205c data in Figure 205d.

LHA 28°, Lat. 15° (Same as Dec.)

Table 205c. Data from Pub. No. 229.

fictitious longitude. . The arc of the fictitious equator between the prime fictitious meridian and any given fictitious meridian. It may be called transverse, oblique, or grid longitude depending upon the type of fictitious meridian.

fictitious loxodrome. . See FICTITIOUS RHUMB LINE.

fictitious loxodromic curve. . See FICTITIOUS RHUMB LINE.

fictitious meridian. . One of a series of great circles or lines used in place of a meridian for certain purposes. A transverse meridian is a great circle perpendicular to a transverse equator; an oblique meridian is a great circle perpendicular to an oblique equator; a grid meridian is one of the grid lines extending in a grid north-south direction. The reference meridian (real or fictitious) used as the origin for measurement of fictitious longitude is called prime fictitious meridian.

fictitious parallel. . A circle or line parallel to a fictitious equator, connecting all points of equal fictitious latitude. It may be called transverse, oblique, or grid parallel depending upon the type of fictitious equator.

fictitious pole. . One of the two points 90° from a fictitious equator. It may be called the transverse or oblique pole depending upon the type of fictitious equator.

fictitious rhumb. . See FICTITIOUS RHUMB LINE.

fictitious rhumb line. . A line making the same oblique angle with all fictitious meridians. It may be called transverse, oblique, or grid rhumb line depending upon the type of fictitious meridian. The expression OBLIQUE RHUMB LINE applies also to any rhumb line, real or fictitious, which makes an oblique angle with its meridians; as distinguished from parallels and meridians real or fictitious, which may be consider special cases of the rhumb line. Also called FICTITIOUS RHUMB, FICTITIOUS LOXODROME, FICTITIOUS LOXODROMIC CURVE.

fictitious ship. . An imaginary craft used in the solution of certain maneuvering problems, as when a ship to be intercepted is expected to change course or speed during the interception run.

fictitious sun. . An imaginary sun conceived to move eastward along the celestial equator at a rate equal to the average rate of the apparent sun or to move eastward along the ecliptic at the average rate of the apparent sun. See also DYNAMICAL MEAN SUN, MEAN SUN.

fictitious year. . The period between successive returns of the sun to a sidereal hour angle of 80° (about January 1). The length of the fictitious year is the same as that of the tropical year, since both are based upon the position of the sun with respect to the vernal equinox. Also called BESSELIAN YEAR.

fidelity. , *n.* The accuracy to which an electrical system, such as a radio, reproduces at its output the essential characteristics of its input signal.

field. . In ECDIS, a named collection of labeled subfield(s). For example, IHO ATTRIBUTE LABEL/CODE and IHO ATTRIBUTE VALUE are collected into a field named Feature Record Attribute.

field glass. . A telescopic binocular.

field lens. . A lens at or near the plane of a real image, to collect and redirect the rays into another part of the optical system; particularly, the eyepiece lens nearest the object, to direct the rays into the eye lens.

field of view. . The maximum angle of vision, particularly of an optical instrument.

figure of the earth. . See GEOID.

file. , *n.* In ECDIS, an identified set of S-57 records collected together for a specific purpose. The file content and structure must be defined by a PRODUCT SPECIFICATION.

filling. , *n.* Increase in atmospheric pressure, particularly within a low. Decrease in pressure is called DEEPENING.

final diameter. . The diameter of the circle traversed by a vessel after turning through 360° and maintaining the same speed and rudder angle. This diameter is always less than the tactical diameter. It is measured perpendicular to the original course and between the tangents at the points where 180° and 360° of the turn have been completed.

final great circle course. . The direction, at the destination, of the great circle through that point and the point of departure, expressed as the angular distance from a reference direction, usually north, to that part of the great circle extending beyond the destination. See also INITIAL GREAT CIRCLE COURSE.

finger rafted ice. . The type of rafted ice in which floes thrust “fingers” alternately over and under the other.

finger rafting. . A type of rafting whereby interlocking thrusts are formed, each floe thrusting “fingers” alternately over and under the other. Finger rafting is common in NILAS and GRAY ICE.

finite. , *adj.* Having limits. The opposite is INFINITE.

fireball. , *n.* See BOLIDE.

firn. , *n.* Old snow which has recrystallized into a dense material. Unlike snow, the particles are to some extent joined together; but, unlike ice, the air spaces in it still connect with each other.

first estimate-second estimate method. . The process of determining the value of a variable quantity by trial and error. The expression applies particularly to the method of determining time of meridian transit (especially local apparent noon) at a moving craft. The time of transit is computed for an estimated longitude of the craft, the longitude estimate is then revised to agree with the time determined by the first estimate, and a second computation is made. The process is repeated as many times as necessary to obtain an answer of the desired precision.

first light. . The beginning of morning nautical twilight, i.e., when the center of the morning sun is 12° below the horizon.

first point of Aries. . See VERNAL EQUINOX.

first point of Cancer. . See SUMMER SOLSTICE.

first point of Capricornus. . See WINTER SOLSTICE.

first point of Libra. . See AUTUMNAL EQUINOX.

first quarter. . The phase of the moon when it is near east quadrature, when the western half of it is visible to an observer on the earth. See also PHASES OF THE MOON.

first-year ice. . Sea ice of not more than one winter's growth, developing from young ice, with a thickness of 30 centimeters to 2 meters. First-year ice may be subdivided into THIN FIRST-YEAR ICE, WHITE ICE, MEDIUM FIRST-YEAR ICE, and THICK FIRST-YEAR ICE.

firth. , *n.* A long, narrow arm of the sea.

Fischer ellipsoid of 1960. . The reference ellipsoid of which the semimajor axis is 6,378,166.000 meters, the semiminor axis is 6,356,784.298 meters, and the flattening or ellipticity is 1/298.3. Also called FISCHER SPHEROID OF 1960.

Fischer ellipsoid of 1968. . The reference ellipsoid of which the semimajor axis is 6,378,150 meters, the semiminor axis is 6,356,768.337 meters, and the flattening or ellipticity is 1/298.3. Also called FISCHER SPHEROID OF 1968.

Fischer spheroid of 1960. . See FISCHER ELLIPSOID OF 1960.

Fischer spheroid of 1968. . See FISCHER ELLIPSOID OF 1968.

fish. , *n.* Any towed sensing device.

fishery conservation zone. . See under FISHING ZONE.

fish havens. . Areas established by private interests, usually sport fishermen, to simulate natural reefs and wrecks that attract fish. The reefs are constructed by dumping assorted junk in areas which may be of very small extent or may stretch a considerable distance along a depth contour. Fish havens are outlined and labeled on charts.

fishing zone. The offshore zone in which exclusive fishing rights and management are held by the coastal nation. The U.S. fishing zone, known as the fishery conservation zone, is defined under P.L. 94-265. The law states, “The inner boundary of the fishery conservation zone is a line conterminous with the seaward boundary of catch of the coastal states, and the outer boundary of such zone is a line drawn in such manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured.”

fish lead. . A type of sounding lead used without removal from the water between soundings.

fish stakes. . Poles or stakes placed in shallow water to outline fishing grounds or to catch fish.

fish trap areas. . Areas established by the U.S. Army Corps of Engineers in which traps may be built and maintained according to established regulations. The fish stakes which may exist in these areas are obstructions to navigation and may be dangerous. The limits of fish trap areas and a cautionary note are usually charted.

fix. , *n.* A position determined without reference to any former position; the common intersection of two or more lines of position obtained from simultaneous observations. Fixes obtained from electronic systems are often given as lat./long. coordinates determined by algorithms in the system software. See also RUNNING FIX.

fixed. . A light which is continuously on.

fixed and flashing light. . A light in which a fixed light is combined with a flashing light of higher luminous intensity. The aeronautical light equivalent is called UNDULATING LIGHT.

a much smaller motion eastward along the ecliptic. The component of general precession along the celestial equator, called precession in right ascension, is about 46.1" per year; and the component along a celestial meridian, called precession in declination, is about 20.0" per year.

General Prudential Rule. . Rule 2(b) of the International Rules (COLREGS) as well as the Inland Navigation and Inland Rules. Rule 2(b) states "In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger."

generating area. . The area in which ocean waves are generated by the wind. Also called FETCH.

gentle breeze. . Wind of force 3 (7 to 10 knots or 8 to 12 miles per hour) on the Beaufort wind scale.

geo. , *n.* A narrow coastal inlet bordered by steep cliffs. Also called GIO.

geo-. . A prefix meaning earth.

geocentric. , *adj*. Relative to the earth as a center; measured from the center of the earth.

geocentric latitude. . The angle at the center of the reference ellipsoid between the celestial equator and a radius vector to a point on the ellipsoid. This differs from the geographic latitude by a maximum of 11.6' of arc at Lat. 45°.

geocentric parallax. . The difference in apparent direction of a celestial body from a point on the surface of the earth and from the center of the earth. This difference varies with the body's altitude and distance from the earth. Also called DIURNAL PARALLAX. See also HELIOCENTRIC PARALLAX.

geodesic. , *adj*. Of or pertaining to geodesy; geodetic.

geodesic. , *n.* See GEODESIC LINE.

geodesic line. . A line of shortest distance between any two points on any mathematically defined surface. A geodesic line is a line of double curvature and usually lies between the two normal section lines which the two points determine. If the two terminal points are in nearly the same latitude, the geodesic line may cross one of the normal section lines. It should be noted that, except along the equator and along the meridians, the geodesic line is not a plane curve and cannot be sighted over directly. Also called GEODESIC, GEODETIC LINE.

geodesy. , *n*. The science of the determination of the size and shape of the earth.

geodetic. , *adj*. Of or pertaining to geodesy; geodesic.

geodetic bench mark. . See under BENCH MARK.

geodetic datum. . See DATUM, HORIZONTAL GEODETIC DATUM, VERTICAL GEODETIC DATUM.

geodetic equator. . The line of zero geodetic latitude; the great circle described by the semimajor axis of the reference ellipsoid as it is rotated about the minor axis. See also ASTRONOMICAL EQUATOR.

geodetic height. . See ELLIPSOIDAL HEIGHT.

geodetic latitude. . The angle which the normal to the ellipsoid at a station makes with the plane of the geodetic equator. It differs from the corresponding astronomical latitude by the amount of the meridional component of the local deflection of the vertical. Also called TOPOGRAPHICAL LATITUDE and sometimes GEOGRAPHIC LATITUDE.

geodetic line. . See GEODESIC LINE.

geodetic longitude. . The angle between the plane of the geodetic meridian at a station and the plane of the geodetic meridian at Greenwich. A geodetic longitude differs from the corresponding astronomical longitude by the amount of the prime vertical component of the local deflection of the vertical divided by the cosine of the latitude. Sometimes called GEOGRAPHIC LONGITUDE.

geodetic meridian. . A line on a reference ellipsoid which has the same geodetic longitude at every point. Sometimes called GEOGRAPHIC MERIDIAN.

geodetic parallel. . A line on a reference ellipsoid which has the same geodetic latitude of every point. A geodetic parallel, other than the equator, is not a geodesic line. In form, it is a small circle whose plane is parallel with the plane of the geodetic equator. See also ASTRONOMICAL PARALLEL.

geodetic position. . A position of a point on the surface of the earth expressed in terms of geodetic latitude and geodetic longitude. A geodetic position implies an adopted geodetic datum.

geodetic satellite. . Any satellite whose orbit and payload render it useful for geodetic purposes.

geodetic survey. . A survey that takes into account the shape and size of the earth. It is applicable for large areas and long lines and is used for the precise location of basic points suitable for controlling other surveys.

geographic, geographical. , *adj*. Of or pertaining to geography.

geographical coordinates. . Spherical coordinates defining a point on the surface of the earth, usually latitude and longitude. Also called TERRESTRIAL COORDINATES.

geographical mile. . The length of 1 minute of arc of the equator, or 6,087.08 feet. This approximates the length of the nautical mile.

geographical plot. . A plot of the movements of one or more vessel relative to the surface of the earth. Also called TRUE PLOT. See also NAVIGATIONAL PLOT.

geographical pole. . Either of the two points of intersection of the surface of the earth with its axis, where all meridians meet, labeled N or S to indicate whether the north geographical pole or the south geographical pole.

geographical position. . 1. That point on the earth at which a given celestial body is in the zenith at a specified time. The geographical position of the sun is also called the sub solar point, of the moon the sublunar point, and of a star the substellar or subastral point. 2. Any position on the earth defined by means of its geographical coordinates either astronomical or geodetic.

geographic graticule. . The system of coordinates of latitude and longitude used to define the position of a point on the surface of the earth with respect to the reference ellipsoid.

geographic information system. . An approach to modeling the world that allows for data in a wide variety of forms to be linked to geographic positioning to aid in decision-making, intelligence, and safety of navigation applications. Database, analysis, and display are separate aspects that multiply the power and usefulness in a digital environment.

geographic latitude. . A general term applying to astronomic and geodetic latitudes.

geographic longitude. A general term applying to astronomic and geodetic longitudes.

geographic meridian. . A general term applying to astronomical and geodetic meridians.

geographic number. . The number assigned to an aid to navigation for identification purposes in accordance with the lateral system of numbering.

geographic parallel. . A general term applying to astronomical and geodetic parallels.

geographic range. . The maximum distance at which the curvature of the earth and terrestrial refraction permit an aid to navigation to be seen from a particular height of eye without regard to the luminous intensity of the light. The geographic range sometimes printed on charts or tabulated in light lists is the maximum distance at which the curvature of the earth and terrestrial refraction permit a light to be seen from a height of eye of 15 feet above the water when the elevation of the light is taken above the height datum of the largest scale chart of the locality. Therefore, this range is a nominal geographic range. See also VISUAL RANGE OF A LIGHT.

geographic sign conventions. . In mapping, charting, and geodesy, the inconsistent application of algebraic sign to geographical references and the angular reference of azimuthal systems is a potential trouble area in scientific data collection. The following conventions have wide use in the standardization of scientific notation: Longitude references are positive eastward of the Greenwich meridian to 180°, and negative westward of Greenwich. Latitude references are positive to the north of the equator and negative to the south. Azimuths are measured clockwise, using South as the origin and continuing to 360°. Bearings are measured clockwise, using North as the origin and continuing to 360°. Tabulated coordinates, or individual coordinates, are annotated N, S, E, W, as appropriate.

geoid. , *n.* The equipotential surface in the gravity field of the earth; the surface to which the oceans would conform over the entire earth if free to adjust to the combined effect of the earth's mass attraction and the centrifugal force of the earth's rotation. As a result of the uneven distribution of the earth's mass, the geoidal surface is irregular. The geoid is a surface along which the gravity potential is

nautical, *adj*. Of or pertaining to ships, marine navigation, or seamen.

nautical almanac. 1. A periodical publication of astronomical data designed primarily for marine navigation. Such a publication designed primarily for air navigation is called an AIR ALMANAC. 2. *Nautical Almanac*; a joint annual publication of the U.S. Naval Observatory and the Nautical Almanac Office, Royal Greenwich Observatory listing the Greenwich hour angle and declination of various celestial bodies to a precision of 0.1' at hourly intervals; time of sunrise, sunset, moon rise, moonset; and other astronomical information useful to navigators.

nautical astronomy. See NAVIGATIONAL ASTRONOMY.

nautical chart. A representation of a portion of the navigable waters of the earth and adjacent coastal areas on a specified map projection, designed specifically to meet requirements of marine navigation.

nautical day. Until January 1, 1925, a day that began at noon, 12 hours earlier than the calendar day, or 24 hours earlier than the astronomical day of the same date.

nautical mile. A unit of distance used principally in navigation. For practical consideration it is usually considered the length of 1 minute of any great circle of the earth, the meridian being the great circle most commonly used. Because of various lengths of the nautical mile in use throughout the world, due to differences in definition and the assumed size and shape of the earth, the International Hydrographic Bureau in 1929 proposed a standard length of 1,852 meters, which is known as the International Nautical Mile. This has been adopted by nearly all maritime nations. The U.S. Departments of Defense and Commerce adopted this value on July 1, 1954. With the yard-meter relationship then in use, the International Nautical Mile was equivalent to 6076.10333 feet, approximately. Using the yard-meter conversion factor effective July 1, 1959, (1 yard = 0.9144 meter, exactly) the International Nautical Mile is equivalent to 6076.11549 feet, approximately. See also SEA MILE.

nautical twilight. The time of incomplete darkness which begins (morning) or ends (evening) when the center of the sun is 12° below the celestial horizon. The times of nautical twilight are tabulated in the *Nautical Almanac*; at the times given the horizon is generally not visible and it is too dark for marine sextant observations. See also FIRST LIGHT.

nautophone, *n*. A sound signal emitter comprising an electrically oscillated diaphragm. It emits a signal similar in power and tone to that of a REED HORN.

Naval Vessel Lights Act. Authorized departure from the rules of the road for character and position of navigation lights for certain naval ships. Such modifications are published in *Notice to Mariners*.

NAVAREA. A geographical subdivision of the Long Range Radio Broadcast Service.

NAVAREA Warnings. Broadcast messages containing information which may affect the safety of navigation on the high seas. In accordance with international obligations, the National Geospatial-Intelligence Agency (NGA) is responsible for disseminating navigation information for ocean areas designated as NAVAREAS IV and XII of the World Wide Navigational Warning Service. NAVAREA IV broadcasts cover the waters contiguous to North America from the Atlantic coast eastward to 35°W and between latitudes 7°N and 67°N. NAVAREA XII broadcasts cover the waters contiguous to North America extending westward to the International Date Line and from 67°N to the equator east of 120°W, south to 3°25′S, thence east to the coast. Other countries are responsible for disseminating navigational information for the remaining NAVAREAS.

navigable, *adj*. Affording passage to a craft; capable of being navigated.

navigable semicircle (less dangerous semicircle). The half of a cyclonic storm area in which the rotary and forward motions of the storm tend to counteract each other and the winds are in such a direction as to tend to blow a vessel away from the storm track. In the Northern Hemisphere this is to the left of the storm center and in the Southern Hemisphere it is to the right. The opposite is DANGEROUS SEMICIRCLE.

navigable waters. Waters usable, with or without improvements, as routes for commerce in the customary means of travel on water.

navigating sextant. A sextant designed and used for observing the altitudes of celestial bodies, as opposed to a hydrographic sextant.

navigation, *n*. The process of planning, recording, and controlling the movement of a craft or vehicle from one place to another. The word navigate is from the Latin navigatus, the past participle of the verb navigere, which is derived from the words navis, meaning "ship," and agere meaning "to move" or "to direct." Navigation of water craft is called marine navigation to distinguish it from navigation of aircraft, called air navigation. Navigation of a vessel on the surface is sometimes called surface navigation to distinguish it from navigation of a submarine. Navigation of vehicles across land or ice is called land navigation. The expression polar navigation refers to navigation in the regions near the geographical poles of the earth, where special techniques are employed.

navigational aid. An instrument, tool, system, device, chart, method, etc., intended to assist in navigation. This expression is not the same as AID TO NAVIGATION, which refers to devices external to a craft such as lights and buoys.

navigational astronomy. Astronomy of direct use to a navigator, comprising principally celestial coordinates, time, and the apparent motions of celestial bodies. Also called NAUTICAL ASTRONOMY.

navigational information. In ECDIS the information contained in MARINER'S NAVIGATIONAL OBJECTS.

navigational planets. The four planets commonly used for celestial observations: Venus, Mars Jupiter, and Saturn.

navigational plot. A graphic plot of the movements of a craft. A dead reckoning plot is the graphic plot of the dead reckoning, suitably labeled with respect to time, direction, and speed; a geographical plot is one relative to the surface of the earth.

navigational purpose. In ECDIS, the specific purpose for which an ENC has been compiled. There are six such purposes; berthing, harbor, approach, coastal, general, and overview.

navigational symbol. See MARINERS' NAVIGATIONAL OBJECTS

navigational triangle. The spherical triangle solved in computing altitude and azimuth and great circle sailing problems. The celestial triangle is formed on the celestial sphere by the great circles connecting the elevated pole, zenith of the assumed position of the observer, and a celestial body. The terrestrial triangle is formed on the earth by the great circles connecting the pole and two places on the earth; the assumed position of the observer and geographical position of the body for celestial observations, and the point of departure and destination for great circle sailing problems. The expression astronomical triangle applies to either the celestial or terrestrial triangle used for solving celestial observations.

navigation, head of. A transshipment point at the end of a waterway where loads are transferred between water carriers and land carriers; also the point at which a river is no longer navigable due to rapids or falls.

navigation lights. Statutory, required lights shown by vessels during the hours between sunset and sunrise, in accordance with international agreements.

navigation mark. See MARK.

navigation/positioning system. A system capable of being used primarily for navigation or position fixing. It includes the equipment, its operators, the rules and procedures governing their actions and, to some extent, the environment which affects the craft or vehicle being navigated.

navigation satellite. An artificial satellite used in a system which determines positions based upon signals received from the satellite.

Navigation Sensor System Interface (NAVSSI). The U.S. Naval version of the electronic chart display and information system (ECDIS). It is integrated with command and control, weapons, and other systems.

Navigation Tables for Mariners and Aviators. See H.O. PUB. NO. 208.

navigator, *n*. 1. A person who navigates or is directly responsible for the navigation of a craft. 2. A book of instructions on navigation, such as the *The American Practical Navigator (Bowditch)*.

NAVSTAR Global Positioning System. See GLOBAL POSITIONING SYSTEM.

NAVTEX. A medium frequency radiocommunications system intended for the broadcast of navigational information up to 200 miles at sea, which uses narrow band direct printing technology to print out MSI and safety messages aboard vessels, without operator monitoring.

Navy Navigation Satellite System. A satellite navigation system of the United States conceived and developed by the Applied Physics Laboratory of the Johns Hopkins University. It is an all-weather, worldwide, and passive system which provides two-dimensional

INMARSAT	International Maritime Satellite Organization.
INS	inertial navigation system.
int.	interval.
Int. Qk.	Interrupted quick flashing.
ION	Institute of Navigation.
I.Q.	interrupted quick flashing.
IR	interference rejection.
IRP	image-retaining panel.
ISLW	Indian spring low water.
ISO	International Order of Standardization, International Organization for Standards; isophase (light).
ITDMA	Incremental Time Division Multiple Access.
ITU	International Telecommunications Union.
IUGG	International Union of Geodesy and Geophysics.
I.U.Q.	interrupted ultra quick flashing.
I.V.Q.	interrupted very quick flashing.
IWW	Intracoastal Waterway.

J – K – L

J	irradiation correction (altitude).
JRCC	Joint Rescue Coordination Center.
K	Kelvin (temperature).
kHz	kilohertz.
km	kilometer, kilometers.
KML	Keyhole Markup Language
KMZ	Keyhole Markup Language Zipped
kn	knot, knots.
L	latitude; lower limb correction for moon.
l	difference of latitude; logarithm, logarithmic.
LAN	local apparent noon.
LANBY	large automatic navigational buoy.
LASH	lighter aboard ship.
LAT	local apparent time.
lat.	latitude.
LF	low frequency.
L.Fl.	long flashing.
LHA	local hour angle.
LHW	lower high water.
LHWI	lower high water interval.
LL	Light List.
LL	lower limb.
LLW	lower low water.
LLWD	lower low water datum.
LLWI	lower low water interval.
Lm	middle latitude; mean latitude.
LMT	local mean time.
LNB	large navigational buoy.
LNG	liquified natural gas.
LPC	Littoral Planning Chart.
LPG	liquified petroleum gas.
Log	logarithm, logarithmic.
Loge	natural logarithm (to the base e).
Log10	common logarithm (to the base 10).
LoL	List of Lights.
Long.	longitude.
LOP	line of position.
LRIT	Long-Range Identification and Tracking.
LSS	Logical AIS Shore Station.
LST	local sidereal time.
Lt.	light.
Lt Ho	light house.
Lt V	light vessel.
LW	low water.
LWD	low water datum.
LWI	low water interval; mean low water lunitidal interval.
LWQ	tropic low water inequality.

M

M	celestial body; meridian (upper branch); magnetic (direction); meridional parts; nautical mile, miles; other ship.
m	meridian (lower branch); meridional difference; meter,(s); U.S. survey mile, miles; end of other ship's true vector; minutes.
MA.	Marine Analyst.
mag.	magnetic; magnitude.
MARAD	United States Maritime Administration.
MB	magnetic bearing.
mb	millibar(s).
MC	magnetic course.
mc	megacycle, megacycles; megacycles per second.
MC&G	mapping, charting and geodesy.
MCPA	minutes to closest point of approach.
MDA	Maritime Domain Awareness.
Mer. Pass.	meridian passage.
MF	medium frequency.
MGRS	military grid reference system.
MH	magnetic heading.
MHHW	mean higher high water.
MHHWL	mean higher high water line.
MHW	mean high water.
MHWI	mean high water lunitidal interval.
MHWL	mean high water line.
MHWN	neap high water or high water neaps.
MHWS	mean high water springs.
MHz	megahertz.
mi.	mile, miles.
MID	Maritime Identification Digit.
mid	middle.
min.	minute(s).
MISLE	Marine Information for Safety and Law Enforcement.
MLLW	mean lower low water.
MLLWL	mean lower low water line.
MLW	mean low water.
MLWI	mean low water lunitidal interval.
MLWL	mean low water line.
MLWN	neap low water or low water neaps.
MLWS	mean low water springs.
mm	millimeters.